Asian Journal of Urology 10 (2023) 58—63

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ajur

Original Article

Retrograde intrarenal surgery for lower pole stones utilizing stone displacement technique yields excellent results

Dor Golomb [a,*], Hanan Goldberg [a,b], Shlomi Tapiero [a], Yariv Stabholz [a], Paz Lotan [a], Abd Elhalim Darawsha [a], Ronen Holland [a], Yaron Ehrlich [a], David Lifshitz [a]

[a] *Department of Urology, Rabin Medical Center-Beilinson Hospital, Petach Tikva, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel*

[b] *Department of Urology, State University of New York Upstate Medical University, Syracuse, NY, USA*

Received 15 July 2020; received in revised form 22 December 2020; accepted 25 June 2021
Available online 10 September 2021

KEYWORDS
Ureteroscopy;
Lower pole stones;
Retrograde intra-renal surgery;
Stone-free rate;
Basketing

Abstract *Objective:* To evaluate the long-term stone-free rate (SFR) of retrograde intrarenal surgery (RIRS) in the treatment of lower pole renal calculi using only basket relocation and identify independent predictors of stone-free status.

Methods: All consecutive patients undergoing RIRS lower pole renal calculi at a single high-volume tertiary center were analyzed retrospectively. Lower pole stones were relocated to the upper pole, where laser lithotripsy was performed. All patients were followed up in the clinic following the surgery and yearly thereafter. The stone-free status was assessed with a combination of an abdominal ultrasound and abdominal X-ray, or an abdominal non-contrast computed tomography if the stones were known to be radiolucent.

Results: A total of 480 consecutive patients who underwent RIRS for treatment of lower pole renal calculi, between January 2012 and December 2018, were analyzed from a prospectively maintained database of 3000 ureteroscopies. With a median follow-up time of 18.6 months, the mean SFR was 94.8%. The procedures were unsuccessful in 26 (5.4%) patients due to unreachable stones. The median stone size of the unreachable stones was 12 mm (range 10—30 mm). Multivariable logistic regression analysis revealed two predictors of SFR for lower pole stones: a small cumulative stone burden (odds ratio [OR]: 0.903, 95% confidence interval [CI]: 0.867—0.941, $p<0.0001$) and preoperative ureteral stent insertion (OR: 0.515, 95% CI: 0.318—0.835, $p=0.007$).

* Corresponding author.
E-mail address: golombdor@gmail.com (D. Golomb).
Peer review under responsibility of Tongji University.

https://doi.org/10.1016/j.ajur.2021.09.001

Conclusion: The long-term SFR of RIRS for the treatment of lower pole stones with basket displacement with appropriate patient selection is high.

1. Introduction

Lower pole renal stones (LPS) constitute approximately 25%—35% of all kidney stones [1]. The optimal management of LPS continues to be a subject of debate originating historically from the limited success of shock wave lithotripsy (SWL) for LPS in comparison to other renal locations. The debate as to the optimal management of LPS continues even in the modern era of advanced retrograde and antegrade endoscopic procedures. Two issues seem to be the focus of the debate. On the one hand the clearance of stone fragments from the lower pole may be decreased in comparison to other locations. On the other hand, endoscopic retrograde access to the lower pole may be more challenging.

The reasons for the lower clearance rate of fragments from the lower pole after SWL are unclear. One plausible explanation is that the gravity-dependent position of the lower pole calyx precludes efficient stone clearance. More specifically, anatomical features such as the length and width of the infundibulum as well as the infundibulo-pelvic angle may have an impact on stone clearance as demonstrated by Elbahnasy et al. [2]. However, not all studies supported these results [3,4]. Of note, several studies suggested that following SWL, residual fragments are commonly found in the lower pole calyces, disregarding where the stone was initially treated. It may be that the lower pole calix serves as "trap" for residual stone fragments that may become a nidus for stone growth [5—7]. No data are available to suggest if such a phenomenon occurs in patients undergoing retrograde intra-renal surgery (RIRS) for LPS.

Multiple studies have evaluated the stone-free rate (SFR) following the management of lower pole stones using flexible ureteroscopy (fURS). In an early study by Grasso et al. [8] the lower pole was not accessible in 7% of cases during fURSs. With the advent of modern fURSs, with 270 degrees of deflection and more, the rate of failed access decreased significantly [9]. Even in the modern literature there is still controversy regarding the lower pole which appears in some studies as an independent predictor of SFR following RIRS [10], while in other studies the lower pole does not have an adverse effect on the results of RIRS [11]. Different definitions of SFR following fURS as well as different surgical techniques may explain some of the discrepancies. Regarding the SFR, some studies refer to surgical success and immediate postoperative imaging while others refer to the 3 months follow-up visit. However, as previously shown for SWL, small fragments can pass in the urine months after the initial procedure. Hypothetically, this may occur less often for LPS.

Differences in surgical technique may have a more profound impact on the results of RIRS for LPS. Dusting versus stone removal and *in-situ* fragmentation versus stone displacement [12] are two of the most important variations of technique. In the current study, our objective was to evaluate the long-term SFR following RIRS for LPS in a large cohort with a standardized instrumentation and technique which included stone displacement into the upper pole, followed by stone fragmentation and removal.

2. Patients and methods

2.1. Study cohort and data collection

The study cohort included data prospectively collected on consecutive patients who underwent RIRS in our department for LPS between January 2012 and December 2018. Patients selected to undergo RIRS had a cumulative stone diameter of 1.5 cm or less as per European Association of Urology and American Urological Association guidelines. Patients younger than 18 years old were excluded from the study, leaving a total of 480 patients. As a tertiary referral center, many of the patients referred to us had a preplaced double-J ureteral stent. The data were prospectively recorded and entered in an institutional review board approved database. Data collected included age-adjusted Charlson comorbidity score, past urological history, imaging data, operative time, hospital stay, SFR, complications, and follow-up data. Renal stone size and location were assessed preoperatively by either non-contrast computed tomography (NCCT) or by a kidney, ureter, bladder (KUB) radiography and renal ultrasonography in cases of a radiopaque stone. The stone size was defined by the greatest diameter of the largest single renal stone, as defined by the European Association of Urology guidelines [13]. Cumulative stone size was recorded in patients with more than one stone. One of two experienced staff surgeons (Lifshitz D and Holland R) was always present in each case, performing the procedure in an identical manner, as per department policy. Residents also participated in the procedure, but always under the guidance and supervision of one of the two staff surgeons.

All patients were seen for a follow-up visit 3 months following the procedure, and yearly thereafter. The stone-free status was assessed routinely with a combination of an abdominal ultrasound and abdominal X-ray, KUB, or an abdominal NCCT if the stones were known to be radiolucent. The initial stone-free status was defined as a single or cumulative stone diameter <3 mm. Stone analysis was preformed using infrared spectroscopy (Bruker Inc., Billerica, MA, USA).

2.2. RIRS technique

RIRS was performed in similar fashion throughout the years. All procedures were done under general anesthesia, unless a specific recommendation for regional anesthesia was made during preoperative evaluation. RIRS was performed as previously discussed [14]. A ureteral access sheath was used routinely, and the most commonly used size was the 12 Fr or 14 Fr (Flexor, ™Cook Medical, Bloomington, IN, USA). Uretero-renoscopy was preformed using a 7 Fr flexible fiberoptic ureteroscope (Flex-X, Flex-X2™, Storz, Tägerwilen, Switzerland). For the LPS, we routinely utilized the stone displacement technique to an upper pole calix to facilitate laser lithotripsy and protect the ureteroscopes from laser fiber failure occurring in acute angulation. Holmium yttrium aluminum-garnet laser lithotripsy was performed with a 200 micron fiber. Fragmentation settings were usually employed (0.8—1.2 J, 8—15 Hz). Meticulous basket retrieval of all stone fragments large enough to be removed by the basket was utilized, as mandated by department policy. An inspection of the entire collecting system under fluoroscopic guidance was performed and all the stone fragments that could be entrapped by a 2.2 Fr zero tip nitinol basket (Cook Medical Inc., IN, USA) or a 1.9 Fr zero tip basket (Boston Scientific, MA, USA) were removed. In cases in which the laser was not utilized due to smaller stone dimeter, the stones were removed intact. At the end of the procedure according to the surgeon's discretion, either a double-J stent with or without a thread or an overnight ureteral catheter was placed. Double-J stents with a thread were removed 5—7 days following surgery.

2.3. Statistical analysis

Descriptive analyses included medians and interquartile range for continuous variables and proportions for discrete variables. For comparison of discrete and continuous variables, the Chi-squared test and the Kruskal-Wallis test were employed, respectively. Multivariable logistic regression analyses assessed the association of various covariates with the success of RIRS for lower pole stone smaller and larger than 10 mm. The a priori included variables in the models included gender (male or female), age in years (continuous variable), number of renal stone (continuous variable), cumulative stone diameter (continuous variable), and presence of a ureteral stent before RIRS (yes/no). All statistical tests were two-tailed and a p-value of <0.05 was considered significant. Statistical analyses were performed using SPSS® statistical software version 23.0 (SPSS Inc., Chicago, IL, USA).

3. Results

Between January 2012 and December 2018, 480 patients underwent RIRS for lower pole renal calculi at our institution. LPS constituted 58% of all stones. Demographic, preoperative, and operative data are presented in Table 1. In the time period analyzed, the surgical procedures were undertaken by two experienced urologists (Lifshitz D and Holland R).

Table 1 Demographic, preoperative, and operative data of the entire cohort stratified by stone location.

Characteristic	Value
Patient, *n*	480
Age, mean (SD), year	53.8 (14.5)
Male, *n* (%)	301 (62.7)
Charlson score, mean (SD)	1.6 (2)
Preoperative hemoglobin, mean (SD), g/dL	13.5 (1.6)
Preoperative creatinine, mean (SD), mg/dL	1.09 (1.5)
Laterality, *n* (%)	
Right	196 (40.8)
Left	260 (54.2)
Bilateral	24 (5.0)
Renal stone, mean (SD), *n*	1.8 (1.2)
Diameter of largest renal stone, mean (SD), mm	8.7 (6.1)
Patients with preoperative double-J stent, *n* (%)	271 (56.5)
Patients with preoperative positive urine culture, *n* (%)	79 (16.5)
Duration of operation, median (range), min	53 (15—168)

SD, standard deviation.

Mean stone size in the lower pole was 8.7 mm (standard deviation [SD] 6.1 mm). Fifty-six point five percent of the patients were pre-stented. Median operative time was 53 min (range 15—168 min). Procedures were unsuccessful in 29 (6.0%) patients with the LPS. The procedures were unsuccessful due to the following reasons: stone unreachable in 26 (5.4%) patients and technical failure in 3 (0.6%). The median stone size of the unreachable stones was 12 mm (range 10—30 mm). Median hospital stay was 1 day. Postoperative complications occurred in 28 cases and included fever (2.3%), urinary tract infection (2.3%), urosepsis (1.0%), and steinstrasse (0.2%) (Table 2). Stone composition is given in Table 2. The SFR with a median follow-up of 18.6 months (range 6—161 months) was 94.8% (Table 2). Ninety-four (19.6%) patients had radiolucent stones and required post-operative follow-up with a NCCT. Multivariable logistic regression analysis revealed two predictors of SFR for lower pole stones: a small cumulative stone burden (OR: 0.903, 95% CI: 0.867—0.941, $p<0.0001$) and preoperative ureteral stent insertion (OR: 0.515, 95% CI: 0.318—0.835, $p=0.007$). The number of renal stones had no impact on SFR (Table 3 and Table 4).

4. Discussion

The significance of LPS location in the modern RIRS era is not clear. Although special consideration is given to LPS location in the various guidelines, the number of studies comparing the results of RIRS by stone location is limited. The poor results of SWL for the LPS may explain the tendency to offer these patients RIRS over SWL. Indeed, in a meta-analysis of seven randomized controlled trials

Table 2 Postoperative complications and follow-up data following treatment of lower pole stones (*n*=480).

Characteristic	Value
Hospital stay, median (range), day	1 (1—14)
Follow-up, median (range), month	18.6 (6—161)
Stone-free rate at long-term follow-up, *n* (%)	455 (94.8)
Stone type, *n* (%)	
Struvite	10 (2.1)
Carbonate apatite	1 (0.2)
Uric acid	37 (7.7)
Cystine	3 (0.6)
Calcium oxalate	167 (34.8)
Calcium phosphate	2 (0.4)
No analysis performed	259 (54.0)
Postoperative complication, *n* (%)	
Fever	11 (2.3)
Urosepsis	5 (1.0)
Perforation of renal pelvis	0
Steinstrasse	1 (0.2)
Urinary tract infection	11 (2.3)
Ureteral stricture	0

Table 3 Multivariable logistic regression models predicting success in RIRS for LPS below 10 mm.

Characteristic	OR	95% CI	*p*-Value
Gender (female)	1.250	0.647—2.414	0.5
Age, year	1.011	0.989—1.033	0.3
Renal stone, *n*	0.924	0.709—1.203	0.5
Cumulative stone diameter, mm	0.893	0.837—0.952	0.001
Ureteral stent prior to procedure	0.511	0.270—0.964	0.03

CI, confidence interval; LPS, lower pole stones; OR, odds ratio; RIRS, retrograde intrarenal surgery.

comparing PCNL, RIRS, and SWL for LPS <20 mm, the overall SFR for RIRS was 91.7% compared to only 54.4% in SWL [15]. Since the rate of LPS is high in patients undergoing RIRS, the possible impact of this stone location on the long-term results of RIRS is of a major concern. More specifically, is the LPS location a negative predictor of success in patients undergoing RIRS? There are few reports in the literature on predictive factors for becoming stone-free following RIRS. Ito et al. [10] reported in 2015 their results on 310 fURS cases comparing different renal stone locations. A multivariable analysis demonstrated that the presence of LPS is an independent negative predictor for SFR (p=0.001) [10]. Conversely, in a study with a similar size cohort, Bernardini et al. [16] concluded that stone size >10 mm (p<0.0001) and multiple stone location (p=0.001) were associated with reduced SFR, but lower pole location did not have any impact on efficacy and morbidity of RIRS. Likewise, Martin et al. [17] reported the results of RIRS in

Table 4 Multivariable logistic regression models predicting success in RIRS for LPS above 10 mm.

Characteristic	OR	95% CI	*p*-Value
Gender (female)	1.158	0.711—1.883	0.5
Age, year	0.991	0.974—1.008	0.2
Renal stone, *n*	0.881	0.731—1.062	0.1
Cumulative stone diameter, mm	0.903	0.867—0.941	<0.0001
Ureteral stent prior to procedure	0.515	0.318—0.835	0.007

CI, confidence interval; LPS, lower pole stones; OR, odds ratio; RIRS, retrograde intrarenal surgery.

162 patients; LPS were present in 89 (54.9%) patients. Stones were inaccessible in 7.8% and 2.7% of cases for patients with or without LPS (p=0.024). On multivariable analysis only the presence of multiple stones, but not a lower pole location, remained as a predictive factor (OR: 3.2, 95% CI: 1.1—8.9; p=0.027).

The current study represents, to the best of our knowledge, the largest series of RIRS analyzing long-term SFR when treating LPS utilizing basket displacement. Unreachable stones were the cause of unsuccessful procedures in only 5.4% of the cases.

These results should be viewed in context with department guidelines, dictating that all LPS relocated whenever possible.

With a median follow-up of 18.6 months, all the patients with a reachable stone (94.8%) were found to be stone-free. Not surprisingly, smaller stone burden was a predictor of long-term SFR. This result should be viewed in context with department guidelines, dictating that all LPS relocated whenever possible. Generally, patients were selected to undergo RIRS for LPS when the stone size was 15 mm or less. If LPS was deemed preoperatively as unmovable, such as a large stone taking the shape of the lower pole calix with a narrow infundibulum, we would probably offer the patient a percutaneous approach. The high SFR for the LPS in the current study is quite similar to the 92% reported for LPS in the meta-analysis by Donaldson et al. [15]. The high SFR in the current study utilizing the stone displacement technique suggested that unlike SWL, residual stone fragments eventually pass in the urine and do not preferentially lodge in the lower pole calix. Kourambas et al. [18] were the first to report on the stone displacement technique showing that the SFR for LPS was significantly higher if stones were relocated (90% *vs.* 83%). Likewise, Schuster et al. [19] showed that SFR was significantly higher if stones were relocated, but only for stones >1 cm (100% *vs.* 29%, p=0.005). In a more recent study, Resorlu et al. [20] reported an 80.6% SFR for LPS; however, the SFR reached 95.2% for relocated LPS.

Our strategy was to relocate all LPS whenever possible and refrain from *in-situ* laser fragmentation in order to reduce damage to the ureteroscopes and possibly increase the SFR. Importantly this approach dictates our patient selection, namely which LPS are relocated.

In our study, we also reported that prestenting was found to be a predictor of long-term SFR on multivariable analysis. This is in line with a previous study by Netsch et al. [21], which reported preoperative ureteral stent placement was associated with a higher SFR when compared with non-stented patients.

There are some limitations of the current study. These include its retrospective design with its inherent selection bias, and the fact that it was conducted at a single institution with only two experienced surgeons involved. Although this ensures a standard technique, the results in a different low volume center with less experienced surgeons may differ. Furthermore, the surgical experience of the two urologists and the endourological equipment improved over the years, which may have had an effect of the long-term SFR. On the other hand, the complexity of stone cases also increased. Another limitation of our study is the non-uniform method of imaging used to assess the SFR. We acknowledge that ultrasound and KUB are not the most sensitive imaging modality for the analysis of the SFR, but they have the clear advantages of accessibility and decreased exposure to ionizing radiation. Such a practical follow-up protocol has been used in many similar studies evaluating the SFR following RIRS [3,5,20–23]. We believe it is reasonable to assume that if all patients would undergo NCCT the actual SFR would be significantly lower, as recently described by York et al. [24]. Furthermore, we could not measure stone density routinely and add these data to the model as a possible predictor for SFR. Additionally, we did not routinely measure the infundibular length, width, and angle in all patients. Finally, stone analysis was only available in approximately 50% of the patients and therefore was not added to the multivariable models.

5. Conclusion

The SFR following RIRS for LPS with basketing and stone displacement yields an excellent long-term SFR with proper patient selection. We believe this is a safe and efficient method in management of LPS that is $<$10 mm.

Author contributions

Study design: Dor Golomb, Ronen Holland, David Lifshitz.
Data acquisition: Dor Golomb, Shlomi Tapiero, Yariv Stabholz, Paz Lotan, Abd Elhalim Darawsha, Yaron Ehrlich.
Data analysis: Dor Golomb, Hanan Goldberg.
Drafting of manuscript: Dor Golomb, David Lifshitz.
Critical revision of the manuscript: David Lifshitz.

Conflicts of interest

The authors declare no conflict of interest.

References

[1] Gurocak S, Kupeli B, Acar C, Tan MO, Karaoglan U, Bozkirli I. The impact of pelvicaliceal features on problematic lower pole stone clearance in different age groups. Int Urol Nephrol 2008;40:31–7.

[2] Elbahnasy AM, Shalhav AL, Hoenig DM, Elashry OM, Smith DS, McDougall EM, et al. Lower caliceal stone clearance after shock wave lithotripsy or ureteroscopy: the impact of lower pole radiographic anatomy. J Urol 1998;159:676–82.

[3] Sorensen CM, Chandhoke PS. Is lower pole caliceal anatomy predictive of extracorporeal shock wave lithotripsy success for primary lower pole kidney stones? J Urol 2002;168:2377–82.

[4] Albala DM, Assimos DG, Clayman RV, Denstedt JD, Grasso M, Gutierrez-Aceves J, et al. Lower pole I: a prospective randomized trial of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy for lower pole nephrolithiasis—initial results. J Urol 2001;166:2072–80.

[5] Zanetti G, Seveso M, Montanari E, Guarneri A, Del Nero A, Nespoli R, et al. Renal stone fragments following shock wave lithotripsy. J Urol 1997;158:352–5.

[6] Hesse A, Brändle E, Wilbert D, Köhrmann KU, Alken P. Study on the prevalence and incidence of urolithiasis in Germany comparing the years 1979 *vs*. 2000. Eur Urol 2003;44:709–13.

[7] Drach GW, Dretler S, Fair W, Finlayson B, Gillenwater J, Griffith D, et al. Report of the United States cooperative study of extracorporeal shock wave lithotripsy. J Urol 1986;135:1127–33.

[8] Grasso M, Ficazzola M. Retrograde ureteropyeloscopy for lower pole caliceal calculi. J Urol 1999;162:1904–8.

[9] Wendt-Nordahl G, Mut T, Krombach P, Michel MS, Knoll T. Do new generation flexible ureterorenoscopes offer a higher treatment success than their predecessors? Urol Res 2010;39:185–8.

[10] Ito H, Sakamaki K, Kawahara T, Terao H, Yasuda K, Kuroda S, et al. Development and internal validation of a nomogram for predicting stone-free status after flexible ureteroscopy for renal stones. BJU Int 2015;115:446–51.

[11] Chautard D, Bigot P, Azzouzi AR, Pichon T, Chautard D, Culty T, et al. Impact of lower pole calculi in patients undergoing retrograde intrarenal surgery. J Endourol 2013;28:141–5.

[12] Auge BK, Dahm P, Wu NZ, Preminger GM. Ureteroscopic management of lower-pole renal calculi: technique of calculus displacement. J Endourol 2002;15:835–8.

[13] Türk C, Neisius A, Petřík A, Seitz C, Skolarikos A, Somani B, et al. European association of Urology guidelines. 2018 edition. The European Association of Urology Guidelines Office; 2018. Available at: http://uroweb.org/guideline/urolithiasis/. [Accessed 1 January 2020].

[14] Goldberg H, Golomb D, Shtabholtz Y, Tapiero S, Creiderman G, Shariv A, et al. The "old" 15 mm renal stone size limit for RIRS remains a clinically significant threshold size. World J Urol 2017;35:1947–54.

[15] Donaldson JF, Lardas M, Scrimgeour D, Stewart F, MacLennan S, Lam TBL, et al. Systematic review and meta-analysis of the clinical effectiveness of shock wave lithotripsy, retrograde intrarenal surgery, and percutaneous nephrolithotomy for lower-pole renal stones. Eur Urol 2015;67:612–6.

[16] Bernardini S, Pastori J, Jacquemet B, Bailly V, Guichard G, Bernardini S, et al. Comparison of the efficacy and morbidity of flexible ureterorenoscopy for lower pole stones compared with other renal locations. J Endourol 2014;28:1183–7.

[17] Martin F, Hoarau N, Lebdai S, Pichon T, Chautard D, Culty T, et al. Impact of lower pole calculi in patients undergoing retrograde intrarenal surgery. J Endourol 2014;28:141–5.

[18] Kourambas J, Delvecchio FC, Munver R, Pichon T, Chautard D, Culty T, et al. Nitinol stone retrieval-assisted ureteroscopic management of lower pole renal calculi. Urology 2000;56:935–9.

[19] Schuster TG, Hollenbeck BK, Faerber GJ, Wolf JS. Ureteroscopic treatment of lower pole calculi: comparison of lithotripsy *in situ* and after displacement. J Urol 2002;168:43–5.

[20] Resorlu EB, Resorlu B, Oztuna D, Oztuna D, Unsal A. The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. Urology 2011;79:61—6.
[21] Netsch C, Knipper S, Bach T, Herrmann TRW, Gross AJ. Impact of preoperative ureteral stenting on stone-free rates of ureteroscopy for nephroureterolithiasis: a matched-paired analysis of 286 patients. Urology 2012;80: 1214—20.
[22] Ito H, Kawahara T, Terao H, Ogawa T, Yao M, Kubota Y, et al. The most reliable preoperative assessment of renal stone burden as a predictor of stone-free status after flexible ureteroscopy with holmium laser lithotripsy: a single-center experience. Urology 2012;80:524—8.
[23] Kilicarslan H, Kaynak Y, Kordan Y, Kaygisiz O, Coskun B, Gunseren KO, et al. Unfavorable anatomical factors influencing the success of retrograde intrarenal surgery for lower pole renal calculi. Urol J 2015;12:2065—8.
[24] York NE, Zheng M, Elmansy HM, Rivera ME, Krambeck AE, Lingeman JE. Stone-free outcomes of flexible ureteroscopy for renal calculi utilizing computed tomography imaging. Urology 2019;124:52—6.